DRAFT

Astronomy and Physics

Technology Development Strategies

Guidance from the OSS Strategic Plan. The Astronomy and Physics Division (A&P) is responsible for a broad range of space missions; specialized airborne, balloon, and ground-based research facilities; and supporting research and analysis activities that pertain to advancing our understanding of astrophysics, cosmology, astrobiology, and fundamental physics. These programs support two major thematic initiatives, the Astronomical Search for Origins (ASO) and the Structure and Evolution of the Universe (SEU).

The scientific investigations envisioned by the ASO and SEU themes address far reaching questions that are intellectually exciting and technologically challenging. The excitement and the challenges are summarized in the Office of Space Science (OSS) Strategic Plan and expanded by each theme's scientific roadmap document. The theme roadmaps layout investigation plans to attack these questions with focused research initiatives and supporting space flight mission concepts. They also include a discussion of the technological barriers that must be overcome to implement each investigation plan.

The technology discussions in the OSS Strategic Plan and the individual ASO and SEU science roadmaps are abstracted from comprehensive Technology Roadmaps developed by specialists within each theme's planning groups, mission study teams, and advisory committees. The Technology Roadmaps lay out development strategies for obtaining or creating the enabling new capabilities that will be needed to implement the OSS Strategic Plan. Thus, the enabling technology needs flow directly from the approved strategic scientific investigation plans.

Technical Directions. The scientific directions of A&P that are envisioned by the OSS Strategic Plan include giant filled aperture cryogenic telescopes, instruments for detection of the polarized component of microwave background radiation, a constellation of individually optimized x-ray telescopes obtaining coordinated observations, an observatory to image and characterize earth-like planets, and spacecraft arrays to detect the gravitational radiation from highly energetic astrophysical events. The preliminary studies of these mission concepts quickly reveal the kinds of enabling technology that A&P must be prepared to understand, define, and manage as part of its science theme stewardship responsibilities.

There are five broad areas into which these key enabling capabilities can be grouped. . The relationship of these five areas of future technical requirements to the strategic science investigations are shown in the following matrix.

Theme	Investigation	Detectors	Optics	Thermal	Structures	Distributed S/C
ASO						
	Planet Search		■	■	■	■
	Cosmic Origins	■	■	■	■	
SEU						
	Gravitational Radiation	■*	■*	■*	■	■
	Black Holes	■	■	■	■	■

- Cosmic Microwave Background measurements reveal the interaction of gravity waves with matter in the early universe

Internal A&P Technology Sources. A&P has two sources on new technology that are supported and managed within its own programs and projects. First, the Research and Analysis Program (R&A) funds technology research, typically in an academic environment, directed at emerging or low TRL capabilities. These are usually technology push activities that leverage modest, short term funding against the possibility of entirely new science capability. The second source is technology developed by individual projects.

During the early definition activities of new A&P flight projects, the technological barriers or risks associated with the mission architecture alternatives must be identified. This process leads to a plan to obtain the needed technologies or otherwise mitigate the development risks they represent. Typically, the project must expend significant early resources to attack these issues. The Terrestrial Planet Finder Project, for example, is almost entirely a collection of critical technology development efforts at this point. The ultimate choice TPF mission architecture depends on the outcome of these various projects.

These internal technology sources are directly within the purview of A&P's programmatic oversight. A&P's responsibility is to insure that the emphasis of these resource investments is directed towards advancing implementation of the Strategic Plan. The programmatic objective is to limit technology development to items that are both mission enabling and that cannot reasonably be expected to be developed in a timely fashion without A&P intervention.

Occasionally -the A&P identifies a key technology need that overlaps multiple projects. This presents the opportunity to improve return on investment by satisfying a number of project requirements with a single technology investment. A recent cryogenic refrigeration development had potential application in three missions that spread across both the ASO and SEU themes. It has been managed in such a way as to make progress towards the common elements of the individual mission needs. However, it is also clear that the development paths eventually diverge and the common project must not be pushed beyond its useful conclusion.

Other NASA Technology Sources. The Office of Aerospace Technologies (OAT) is responsible for investments in NASA driven technologies, targeting early TRL but extending to mid TRL values that are required to decrease risk for future flight applications.
The OAT program is one specific source of precursor technology options that can be applied to A&P flight project needs. The SIRTF, JWST, and SIM missions have benefited from previous OAT initiated technology. However, OAT is subject to constraints on its investment priorities that are well beyond A&P or even OSS influence. They have customers from other NASA enterprises who compete for their support.

The Small Business Innovative Research (SBIR) program provides a valuable resource to engage innovative commercial enterprises through a well-funded competitive process. A&P does control the content of a portion of the annual SBIR solicitation and has obtained very useful small business scale technology as a result. Active optical wavefront correction technology is one example. Advances in specialized extreme ultraviolet filter technology is another.

The final stages of the technology development process usually call for validation of the technology for space flight. The New Millennium Program provides OSS with a mechanism for rapid flight validation and offers A&P a means to achieve low cost flight validation when necessary.

Technology Development Partnerships. Partnerships offer the opportunity to distribute the costs and oversight burdens of technology creation beyond the limitations of a single organization to a group of users who share common objectives. Pooling of resources, workforce, and influence may be the only practical way to achieve a challenging goal that is beyond the scope of each individual member. The creation of the low areal density mirror panel technology for the James Webb Space Telescope is a recent example of successful partnering. This partnership known as the Advanced Mirror System Demonstrator program (AMSD) between NASA, the United States Air Force, and the National Reconnaissance Office achieved many of each institution's desired goals.
It is unlikely that the resulting technology for large deployable telescope apertures could have been achieved individually by any of the partners/

A&P technology needs are attractive candidates for partnering beyond NASA, The Air Force and the Intelligence Community have similar technology needs for the components of large space optical systems. The National Institute of Science and Technology may

share interest in the metrology systems desired for planet detection interferometers and gravitational wave observatories. The Department of Energy and their laboratories may be candidates for future partnerships as they expand the use of astrophysical phenomenon as tools in understanding the core building blocks of matter and energy.

Foreign partnerships, typically with the European Space Agency (ESA), ESA members, or other nations such as Japan and Russia, offer the full range of technology development and validation opportunities. However, these partnerships are burdened with the highest levels of programmatic risk, communication difficulties, US national security constraints, and cultural differences.